Claims

1. A computerized method for estimating impulse response of a wideband communication channel represented as a linear combination of L time-shifted pulses $p_l(t)$ with propagation coefficients a_l, comprising:

(a) obtaining an ultra-wideband signal received over the channel, filtered with a lowpass/bandpass filter and sampled uniformly at a sub-Nyquist rate;

(b) determining discrete-Fourier-transform coefficients y_j and s_j from the sampled received signal and a transmitted ultra-wide-band pulse, respectively;

(c) determining dominant singular vectors of a matrix having y_{j+i-1}/s_{j+i-1} as its i,j-elements;

(d) estimating a plurality of signal poles from the dominant singular vectors and determining the time shifts from the estimated signal poles; and

(e) determining the propagation coefficients from a system of linear equations.

2. A computerized method for estimating impulse response of a wideband communication channel represented as a linear combination of L time-shifted pulses $p_l(t)$ with propagation coefficients a_l, comprising:

(a) obtaining an ultra-wideband signal received over the channel, filtered with a lowpass/bandpass filter and sampled uniformly at a sub-Nyquist rate;

(b) determining discrete-Fourier-transform coefficients y_j and s_j from the sampled received signal and a transmitted ultra-wide-band pulse, respectively;

(c) determining dominant singular vectors of a matrix having y_{j+i-1}/s_{j+i-1} as its i,j-elements;

(d) estimating a plurality of powers of the signal poles from the dominant singular vectors and determining the time shifts from the estimated powers; and

(e) determining the propagation coefficients from a system of linear equations.

3. The method of claim 2, wherein the communication channel comprises close-spaced paths.

4. The method of claim 1 or 2, wherein the pulses $p_i(t)$ comprise delta pulses.

5. The method of claim 1 or 2, wherein the pulses $p_i(t)$ are substantially the same.

6. The method of claim 1 or 2, wherein the estimated discrete-Fourier-transform coefficients of each of the pulses $p_i(t)$ are approximated by a polynomial whose degree does not exceed an integer R.

7. The method of claim 1 or 2, wherein L is chosen as the number of dominant singular vectors in step (c).

8. The method of claim 1 or 2, wherein the representation is of reduced rank and L is chosen as less than the number of dominant singular vectors in step (c).

9. The method of claim 1 or 2 effected repeatedly, first with the signal sampled at a first sub-Nyquist rate over a first time interval yielding a first estimate of sequence timing, followed by the signal sampled over a second time interval shorter than the first time interval and at a second sub-Nyquist rate greater than the first rate, yielding a second, improved estimate.

10. A system for estimating impulse response of a wideband communication channel represented as a linear combination of L time-shifted pulses $p_i(t)$ with propagation coefficients a_i, comprising:

(a) a functionality for obtaining an ultra-wideband signal received over the channel, filtered with a lowpass/bandpass filter and sampled uniformly at a sub-Nyquist rate;

(b) a functionality for determining discrete-Fourier-transform coefficients y_j and s_j from the sampled received signal and a transmitted ultra-wide-band pulse, respectively;

(c) a functionality for determining dominant singular vectors of a matrix having y_{j+i-1}/s_{j+i-1} as its i,j-elements;

(d) a functionality for estimating at least a first power of signal poles from the dominant singular vectors and determining the time shifts from the estimated at-least-first-power of the signal poles; and

(e) a functionality for determining the propagation coefficients from a system of linear equations.

11 A system for estimating impulse response of a wideband communication channel represented as a linear combination of L time-shifted pulses $p_l(t)$ with propagation coefficients a_l, comprising:

(a) a functionality for obtaining an ultra-wideband signal received over the channel, filtered with a lowpass/bandpass filter and sampled uniformly at a sub-Nyquist rate;

(b) a functionality for determining discrete-Fourier-transform coefficients y_j and s_j from the sampled received signal and a transmitted ultra-wide-band pulse, respectively;

(c) a functionality for determining dominant singular vectors of a matrix having y_{j+i-1}/s_{j+i-1} as its i,j-elements;

(d) a functionality for estimating a plurality of powers of the signal poles from the dominant singular vectors and determining the time shifts from the estimated powers; and

(e) a functionality for determining the propagation coefficients from a system of linear equations.

12. The system of claim 11, wherein the communication channel comprises close-spaced paths.

13. The system of claim 10 or 11, wherein the pulses $p_l(t)$ comprise delta pulses.

14. The system of claim 10 or 11, wherein the pulses $p_l(t)$ are substantially the same.

15. The system of claim 10 or 11, wherein the estimated discrete-Fourier-transform coefficients of each of the pulses $p_l(t)$ are approximated by a polynomial whose degree does not exceed an integer R.

16. The system of claim 10 or 11, further comprising a functionality for choosing L as the number of dominant singular vectors determined by functionality (c).

17. The system of claim 10 or 11, wherein the representation is of reduced rank, and the system comprises a functionality for choosing L as less than the number of dominant singular vectors determined by functionality (c).

18. The system of claim 10 or 11 comprising a functionality for repetition, first with the signal sampled at a first sub-Nyquist rate over a first time interval yielding a first estimate of sequence timing, followed by the signal sampled over a second time interval shorter than the first time interval and at a second sub-Nyquist rate greater than the first rate, for yielding a second, improved estimate.